2. Methodology

EPA evaluates potential water quality effects of direct discharges on receiving streams and of indirect discharges on POTW operations and their receiving streams using stream modeling techniques, as described in Sections 2.1.1 and 2.1.2. Direct discharge facilities are those which discharge directly into water bodies usually following on-site wastewater treatment. Indirect discharge facilities are those which discharge facility effluent into a publicly owned treatment works (POTWs), which provides subsequent treatment of the facility effluent.

EPA evaluated potential aquatic life and human health effects resulting from current and projected contaminant releases separately for the three final subcategories of CWT operations. The categories are as follows: Metal-Bearing Waste Treatment and Recovery Operations (metals), Used/Waste Oil Treatment and Recovery Operations (oils), and Organic Waste Treatment (organics). Many facilities fall into multiple subcategory combinations.[1] EPA also assessed the effects on POTWs that treat effluent from CWT facilities (Section 2.2). These effects may include biological upset of treatment processes and sewage biosolids toxicity.

EPA assessed potential effects on aquatic life by comparing modeled in-stream concentrations to EPA's aquatic life ambient water quality criteria (AWQCs). Where EPA has not developed water quality criteria, EPA uses other values representative of that chemical's aquatic toxicity. The Agency compares modeled in-stream concentrations to both acute and chronic AWQCs when available.

EPA estimates potential effects on human health in the following manner. EPA first compares modeled in-stream contaminant concentrations for each facility by subcategory under baseline conditions and for the final limitations and standards. EPA compares these instream concentrations to health-based toxic effect values derived using standard EPA methodology. Next, EPA estimates potential carcinogenic risks and noncarcinogenic hazards to the recreational and subsistence angler populations and their households due to the consumption of contaminated fish. EPA also estimates exposure to contaminants through the water

[1] Many CWT facilities treat wastes from multiple subcategories. Therefore, EPA aggregated loadings from each subcategory to estimate the combined environmental effects of the final rule.

pathway by comparing modeled in-stream contaminant concentrations to health-based AWQCs for the ingestion of water and organisms.

2.1 Estimating In-Stream Concentrations

EPA estimates in-stream contaminant concentrations for various flow conditions as the first step in evaluating effects on aquatic life and human health. EPA uses treatment data collected from industry and EPA sampling data to estimate contaminant loadings discharged at each facility under baseline conditions and under the final rule. Chapter 12 of the final technical development document (EPA 821-R-00-023) for the final rule explains the methodology EPA used to estimate current and post-compliance pollutant loadings. The following subsections describe the methodology and assumptions EPA uses to evaluate effects of direct and indirect discharging facilities on human health and aquatic life.

2.1.1 Direct Discharge Facilities

EPA projects in-stream concentrations for current and final rule BPT/BAT treatment levels using a simple stream dilution model that does not account for fate and transport processes (see Equation 1).[2]

$$C_{is} = \frac{L/OD}{FF+SF} \times CF \qquad \textbf{(1)}$$

where:

C_{is}	=	in stream pollutant concentration (µg/L);
L	=	facility pollutant loading (lb/year);
OD	=	facility operation (days/year);
FF	=	facility flow (million gallons per day (MGD));
SF	=	receiving stream flow (MGD); and
CF	=	conversion factor 120 (µg MG / L lbs) = 0.2642 (gal/L) x 0.4536 (kg/lbs) x 10^3 (µg MG / kg gal).

[2] Equations used to estimate instream concentrations are adapted from methodology presented in "*Technical Support Document for Water Quality-Based Toxics Control*, EPA, March 1991.

EPA obtains the facility-specific data (i.e., pollutant loading, operating days, and facility flow) used in Equation 1 from the sources described in Section 3.1 of this report. In all, EPA uses three different values for receiving stream flow rate (1Q10 low flow, 7Q10 low flow, and harmonic mean flow (HMF)) for the current and final regulatory options. The 1Q10 and 7Q10 low flows are used to evaluate the potential for acute and chronic aquatic toxicity, respectively, in receiving streams, as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (USEPA, 1991a).[3] EPA uses the HMF to estimate the potential for human health effects.[4] Neither the 1Q10 nor 7Q10 flow is appropriate for assessing potential human health effects because neither has a consistent relationship with the long-term mean dilution.

Because EPA is not able to obtain stream flows for hydrologically complex waters such as bays, estuaries and oceans, EPA uses site-specific critical dilution factors (CDFs) with Equation 2 to predict pollutant concentrations for facilities discharging to these complex water bodies. EPA uses site-specific CDFs developed from a 1992 survey of states and EPA Regions conducted by EPA's Office of Pollution Prevention and Toxics (OPPT).

$$C_{es} = \left[\left(\frac{L/OD}{FF} \right) \times CF \right] / CDF \qquad \textbf{(2)}$$

where:

C_{es}	=	estuary pollutant concentration (µg/L);
L	=	facility pollutant loadings (lb/year);
OD	=	facility operation (days/year);
FF	=	facility flow (MGD);
CDF	=	critical dilution factor (unitless); and
CF	=	conversion factor = 120 (µg MG / L lbs).

[3] The 1Q10 and 7Q10 flows, respectively, are the lowest 1-day and lowest consecutive 7-day average flow during any 10-year period.

[4] The harmonic means are determined by taking the reciprocal of the mean value of the reciprocal of individual values. EPA recommends that the long-term harmonic mean flow be used for assessing potential human health effects because it provides a more conservative estimate than the arithmetic mean flow.

When EPA cannot obtain CDFs directly, EPA uses dissolved concentration potentials (DCPs) with Equation 3 to calculate the CDF. EPA obtains DCPs from the Strategic Assessment Branch of the National Oceanic and Atmospheric Administration's (NOAA) Ocean Assessments Division. NOAA developed DCPs based on freshwater inflow and salinity gradients to predict pollutant concentrations in each estuary in the National Estuarine Inventory (NEI) Data Atlas. These DCPs are applied to predict concentrations of nonreactive dissolved substances. In addition, the DCPs reflect the predicted estuary-wide response and might not be indicative of site-specific locations. If neither DCPs nor CDFs are available for an estuary receiving discharges from CWT facilities, EPA estimates a CDF based on best professional judgement of the size, depth, and location of the receiving water body. Appendix A provides DCP values used for specific water bodies.

$$CDF = \frac{BL \times CF}{DCP \times OD \times FF} \tag{3}$$

where:

CDF	=	critical dilution factor (unitless);
BL	=	benchmark load = 10,000 (tons/yr);
DCP	=	dissolved concentration potential (mg/L);
OD	=	facility operation (days/year);
FF	=	facility flow (MG / day); and
CF	=	conversion factor = 239.68 (mg MG/ ton L) = 907.2 (kg/ton) 10^6 (mg/kg) x 10^{-6} (MG/gal) x 0.2642 (gal/L).

In summary, EPA estimates in-stream (Equation 1) or estuary (Equation 2 or 3) pollutant concentrations for direct discharge facilities to evaluate whether either human health criteria or ambient water quality criteria are exceeded. EPA sums pollutant loadings for individual subcategories before calculating concentrations from multiple subcategory CWTs. When evaluating the combined effects, (combinations of the treatment technology that form the basis for each of the final subcategories), EPA determines water body concentrations by first summing pollutant loadings from all CWT facilities.

2.1.2 Indirect Discharge Facilities

EPA estimates in-stream concentrations for current and final PSES requirements using a simple stream dilution model that does not account for fate processes but does account for POTW influences (see Equation 4). Note that Equation 4 and Equation 1 differ to account for the additional dilution provided by the POTW flow and the removal of pollutants by POTW treatment processes. Sections 3.1 and 3.2 of this report describes the sources the facility-specific data used in Equation 4.

$$C_{is} = (L/OD) \times \frac{(1 - TMT) \times CF}{PF + SF} \tag{4}$$

where:

C_{is}	=	in stream pollutant concentration (µg/L);
L	=	facility pollutant loading (lb/year);
OD	=	facility operation (days/year);
TMT	=	POTW treatment removal efficiency (unitless);
PF	=	POTW flow (MGD);
SF	=	receiving stream flow (MGD); and
CF	=	conversion factor = 120 (µg MG / L lbs).

EPA predicts pollutant concentrations of hydrologically complex water bodies, such as bays, estuaries, and oceans, that received POTW discharges using Equation 5 and site-specific CDFs.

$$C_{es} = \left[\left(\frac{L/OD \times (1 - TMT)}{PF} \right) \times CF \right] / \ CDF \tag{5}$$

Where:

C_{es}	=	estuary pollutant concentration (µg/L);
L	=	facility pollutant loading (lb/year);
OD	=	facility operation (days/year);

TMT = POTW treatment removal efficiency (unitless);

PF = POTW flow (MGD);

CDF = critical dilution factor (unitless); and

CF = conversion factor = 120 (µg MG / L lbs).

When EPA cannot obtain a CDF directly, EPA uses estuarine DCPs with Equation 4 to calculate that CDF. If neither DCPs nor CDFs are available for estuaries receiving discharges from CWT facilities, EPA estimates a CDF based on best professional judgment of the size, depth, and location of the receiving water body. Appendix A provides the DCP values used for specific water bodies.

EPA sums pollutant loadings for individual subcategories before calculating concentrations for POTWs receiving effluent from multiple subcategory CWT facilities. When evaluating the combined effects (combinations of the treatment technologies basis for each of the final subcategories), EPA determines water body concentrations by first summing contaminant loadings from all CWT facilities discharging to each POTW.

2.2 Estimating POTW Effects

EPA calculates effects on POTW operations based either on inhibition of POTW processes (i.e., inhibition of activated sludge or biological treatment), or contamination of POTW sewage biosolids (thereby limiting a POTW's ability to use the biosolids for land application). EPA determines inhibition of POTW operations by comparing calculated POTW influent levels (Equation 6) with available inhibition levels (see Table 3-1).

$$C_p = C_{dj} + \frac{L/OD}{PF} \times CF \qquad \textbf{(6)}$$

where:

C_p = average POTW influent concentration with load contribution of facility (µ/L);

C_{dj} = average POTW influent concentration for chemical *j* due to other sources (µ/L);

L = facility pollutant loading (lb/year);

OD = number of operating days for each facility (days/year);

PF = POTW flow (MGD); and

CF = conversion factor = 120 (µg MG / lbs L).

The term C_{dj} in Equation 6 represents the contribution of other sources (non-CWT pollutant loads) to the average POTW concentration—a contribution that varies among POTWs. In the absence of specific knowledge of each POTW, EPA conservatively estimates C_{dj} by multiplying the reported chemical-specific upset criterion by 0.75.[5]

EPA evaluates potential contamination of sewage biosolids by comparing projected pollutant concentrations in the biosolids (Equation 7) with regulatory values for land application of sewage biosolids. EPA uses two sets of regulatory criteria to characterize projected POTW biosolids concentrations (see Table 3-2).

$$C_{sp} = C_{dp} + \left(\frac{L}{OD_{POTW}} \times \frac{TMT}{PF \times SG} \times CF\right) \qquad \textbf{(7)}$$

where:

C_{sp} = biosolids pollutant concentration (µg/L);
C_{dp} = average POTW biosolids pollutant concentration in typical domestic biosolids (mg/kg dry);
L = facility pollutant loading (lb/year);
TMT = POTW treatment removal efficiency (unitless);
PF = POTW flow (million gallons/year);
SG = biosolids generation factor (lb dry/million gallons treated); and
CF = conversion factor = 10^6 (mg/kg) = (0.4536 kg/lb)/(0.4536 kg_{dry}/lb_{dry}) x 10^6 (mg/kg)2.3

[5] Seventy-five percent of the biological inhibition threshold for a given pollutant activated sludge treatment processes is assumed to be comprised of non-CWT sources. The remaining 25 percent limit is available for CWT sources. Threshold levels used were obtained from *CERCLA Site Discharges to POTW's: Guidance Manual,* EPA 1990.

2.3 Assumptions and Caveats

EPA makes the following assumptions in this analysis:

- EPA models CWT facilities if the receiving streams or the POTWs to which they discharge could be identified (113 of the 205 facilities).
- Aquatic life and human health effects were estimated based on 113 facilities for which facility - specific data are available.
- CWT facilities operate 260 days per year.
- Discharges from CWT contribute produce only a small portion of the total POTW (domestic) biosolids.
- The process water at each facility and the water discharged to a POTW are obtained from a source other than the receiving stream.
- The pollutant load to the receiving stream is continuous and representative of long-term facility operations. This assumption might overestimate risks to human health and aquatic life.
- Complete mixing of discharge flow and stream flow occurs across the stream at the discharge point. This mixing results in the calculation of an "average stream" concentration even though the actual concentration might vary across the width and depth of the stream.
- EPA did not consider pollutant fate processes such as sediment adsorption, volatilization, and hydrolysis. This approach might result in estimated in-stream concentrations that are environmentally conservative (higher).
- The study only evaluates the potential for metal contamination of sewage biosolids to levels that would prohibit its land application as a fertilizer or soil conditioner. Biosolids criteria levels are only available for 7 pollutants: arsenic, cadmium, copper, lead, mercury, selenium & zinc.
- The analysis dilutes pollutant loadings in 1,400 pounds of primary sludge per million gallons treated.

- The 1Q10 and 7Q10 receiving stream flow rates are used to estimate aquatic life effects, and harmonic mean flow rates to estimate human health effects. The analysis estimates 1Q10 low flows using the results of a regression analysis of 1Q10 and 7Q10 flows from representative U.S. rivers and streams conducted by Versar Inc. for EPA's OPPT (Versar, 1992). The analysis estimates harmonic mean flows from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water-Quality-based Toxics Control* (USEPA, 1991a). These flows might not be the same as those used by specific states to assess effects.

- The analysis uses an exposure duration of 365 days to determine the likelihood that human health criteria or toxic effect levels will be exceeded.

- The analysis uses water quality criteria or toxic effect levels developed for freshwater organisms to analyze facilities discharging to estuaries or bays.

2.4 Compiling Documented Environmental Effects

During the months of June through September 1997, EPA contacted EPA Regional and State Pretreatment Coordinators regarding effects of CWT discharges on POTWs and surface waters (see Table 4-27). EPA reviewed State 304(l) Short Lists (USEPA, 1991b) for evidence of documented environmental effects on aquatic life, human health, POTW operations, and the quality of receiving water due to discharges of pollutants from CWT facilities (see Tables 4-28 and 4-29). EPA also reviewed the Permit Compliance System (PCS) data.

2.5 Estimating Toxic Effects

2.5.1 Estimating Effects on Aquatic Life

EPA evaluates potential effects on aquatic life on a site-specific basis by comparing modeled in-stream contaminant concentrations under baseline conditions and following adoption of the final rule using aquatic life criteria and toxicity values (acute and chronic AWQCs). EPA compares the in-stream concentrations for each chemical discharged from each facility under 1Q10 and 7Q10 flow conditions to acute and chronic AWQCs, respectively. EPA first determines whether the discharge of any of the 104 pollutants will exceed the AWQC for that pollutant in a given stream. Next, EPA totals these to obtain the number of in-stream concentrations that exceed one or more AWQC for the 41 water bodies examined.

2.5.2 Estimating Effects on Human Health

EPA estimates potential effects on human health in the following manner. EPA first compares modeled in-stream contaminant concentrations for each subcategory under baseline conditions and following adoption of the final limitations and standards. EPA compares these instream concentrations to health-based toxic effect values[6] derived using standard EPA methodology. Next EPA estimates potential carcinogenic risks and noncarcinogenic hazards to the recreational and subsistence angler population due to the consumption of contaminated fish. Finally, EPA estimates both the annual incidence of cancer and potential lead related health effects in the potentially exposed angler population. Each of these techniques is discussed in more detail below.

(a) Human Health AWQCs

EPA uses the modeled in-stream HMF concentration for estimation of human health AWQ. It is more reflective of average water body conditions then 1Q10 or 7Q10 flow conditions, because health-based AWQCs are derived for lifetime exposure conditions rather than for subchronic or acute conditions. EPA first determines whether the discharge of any of the 104 pollutants will exceed the health based AWQC for that pollutant in a given stream. Next, EPA totals these to obtain the number of in-stream concentrations that exceed one or more of the health based AWQC for the 87 water bodies examined. EPA divides the predicted in-stream concentration under HMF conditions by the health-based AWQC for each chemical discharged from each facility under the final rule and baseline conditions. The sum of these represents in-stream concentrations of specific pollutants that exceed AWQCs as a result of CWT discharges to 87 water bodies from the 113 facilities examined.

(b) Carcinogenic Risks and Noncarcinogenic Hazards

Next, EPA evaluates potential effects on human health by estimating potential carcinogenic risks and noncarcinogenic hazards. EPA performs this assessment in accordance with available EPA guidance including *Risk Assessment Guidance for Superfund* (USEPA, 1989a) and *Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish: A Guidance Manual* (USEPA, 1989b). As outlined in EPA guidance, the technical approach for conducting a risk assessment involves a three-step process:

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[6] The report refers to these either as human health ambient water quality criteria, or health-based AWQCs.

(1) **Toxicity Assessment**. EPA uses available human health toxic effect values for the contaminants of potential concern derived from data sources such as IRIS (USEPA, 1997a), and HEAST (USEPA, 1996). The list of chemicals of potential concern, with their available reference dose values (RfD) and cancer slope factors (SF) are in Appendix B.

(2) **Exposure Assessment.** The exposure assessment involves identifying exposure pathways of concern, estimating exposure point concentrations, and estimating chronic daily intakes.

- Identifying Exposure Pathways of Concern. EPA identifies water-related exposure pathways and target populations. Pathways quantitatively evaluated include only the ingestion of fish by recreational and subsistence anglers.
- Estimating Exposure Point Concentrations. The exposure point concentration (EPC) is the average concentration contacted over the duration of the exposure period. For the fish ingestion pathway, EPA calculates fish tissue EPCs by multiplying the contaminant-specific BCF by the estimated in-stream concentration under HMF conditions using the simple dilution model.
- Estimating Chronic Daily Intakes. EPA estimates chronic daily intakes (CDIs) using exposure models from EPA guidance for each chemical discharged from a facility under each regulatory option and baseline conditions. EPA expresses CDIs in terms of milligrams of contaminant contacted per kilogram of body weight per day (mg/kg/day). EPA calculates a CDI by combining the EPC and exposure parameter estimates (e.g., ingestion rate, exposure frequency, exposure duration, body weight, averaging time) using a chemical intake equation. EPA estimates CDIs for evaluating both carcinogenic risks (based on a lifetime average daily dose) and noncarcinogenic hazards (based on an average daily dose during the exposure period). EPA estimates CDIs for both baseline conditions and final regulatory options.

The equation and exposure parameter values used to estimate CDIs for ingestion of fish is presented below:

$$CDI = \frac{EPC \times BCF \times CF \times IR \times EF \times ED}{BW \times AT} \qquad \textbf{(8)}$$

where:

CDI	=	chronic daily intake (mg/kg/day);
EPC	=	exposure point concentration (in-stream concentration under HMF conditions, in μg/L);
CF	=	conversion facto r= 10^{-6} (kg mg / g μg)
BCF	=	bioconcentration factor (liters/kg)
IR	=	ingestion rate (for the recreational and subsistence anglers, EPA assumes fish consumption rates of at 16.6 grams/day and 140 grams/day, respectively);
EF	=	exposure frequency (365 days/year);
ED	=	exposure duration (70 years);
BW	=	body weight (70 kg); and
AT	=	averaging time = 25,500 (days) = (70 years x 365 days/year).

(3) **Risk Characterization**. EPA assesses carcinogenic risks and noncarcinogenic hazards for chemicals using available toxicity criteria for the pathways quantitatively evaluated in this study.

Carcinogenic Risk Calculations

EPA expresses the potential carcinogenic risks associated with the discharges as an increased probability of developing cancer over a lifetime (e.g., excess individual lifetime cancer risk)(USEPA, 1989a). EPA estimates carcinogenic risks using the equation below:

$$Cancer\ risk_i = CDI_i \times SF_i \qquad \textbf{(9)}$$

where:

Cancer $risk_i$=		potential carcinogenic risk associated with exposure to chemical *I* (unitless);
CDI_i	=	chronic daily intake for chemical *I* (mg/kg/day); and

Sf_i = slope factor for chemical *I* ((mg/kg/day)$^{-1}$).

If the carcinogenic risk exceeds 10^{-2}, EPA guidance (USEPA, 1989a) recommends using the following equation to estimate carcinogenic risk:

$$Cancer\ risk_i = 1 - e^{(-CDI_i \times SF_i)} \tag{10}$$

where:

$Cancer\ risk_i$ = potential carcinogenic risk associated with exposure to chemical *I* (unitless);

CDI_i = chronic daily intake for chemical *I* (mg/kg/day); and

Sf_i = slope factor for chemical *I* ((mg/kg/day)$^{-1}$)

EPA sums chemical-specific cancer risks in accordance with EPA guidance (USEPA, 1989a) to estimate the combined cancer risks associated with exposure to a chemical mixture. EPA estimates the total potential carcinogenic risk for each exposure pathway, for each facility, and for each regulatory option and baseline conditions.

Noncarcinogenic Hazard Calculations

EPA evaluates noncarcinogenic hazards by comparing the estimated dose (e.g., CDI) with a reference dose (RfD). EPA calculates the hazard quotient, which is used to estimate the potential for an adverse noncarcinogenic effect to occur, using the following equation:

$$HQ_i = \frac{CDI_i}{RfD_i} \tag{11}$$

where:

Hq_i = hazard quotient for chemical *I* (unitless);

CDI_i = chronic daily intake for chemical *I* (mg/kg/day); and

RfD_i = reference dose for chemical *I* (mg/kg/day).

If the hazard quotient exceeds unity (1), an adverse effect might occur. The higher the hazard quotient, the more likely that an adverse noncarcinogenic effect will occur as a result of exposure to the chemical. If the estimated hazard quotient is less than unity, an adverse noncarcinogenic effect is highly unlikely to occur.

EPA recommends summing chemical-specific hazard quotients for contaminants with similar endpoints to evaluate the combined noncarcinogenic hazard from exposure to a chemical mixture (USEPA, 1989a). The sum of the chemical-specific hazard quotients is called the hazard index. Using this approach assumes that chemical-specific noncarcinogenic hazards are additive. Limited data are available for actually estimating the potential synergistic and/or antagonistic relationships between chemicals in a chemical mixture. This assessment sums, only the hazard quotients that have similar target organs and toxicological mechanisms.

2.6 Estimating Human Health Risks Associated with Consumption of Lead-Contaminated Fish

Because discharges from several CWT metals and oils facilities contain significant quantities of lead, EPA separately analyzes potential human health risks associated with the consumption of lead-contaminated fish by recreational and subsistence anglers. Ingestion of lead has been shown to cause adverse health effects in both child and adult populations. Elevated blood lead levels in children may impair intellectual development as measured by reduced IQ levels. Adult ingestion of lead may cause numerous cardiovascular problems, including hypertension, coronary heart disease, and strokes. These ailments may cause premature death, particularly in adults aged 40-75 years old. In addition, elevated blood lead levels in pregnant women may increase of the risk of neonatal mortality. EPA estimates the potential for such effects by adapting methodologies developed for assessing human health risks from lead at CERCLA/RCRA sites and for estimating the benefits of the Clean Air Act.

EPA estimates blood lead levels in children using EPA's "Integrated Exposure Uptake Biokinetic Model for Lead in Children" (IEUBK-USEPA,1994a). This PC-based model allows the user to estimate the geometric mean blood lead concentration for a hypothetical child or population of children. Using information on children's exposure to lead, the model estimates a plausible distribution of blood lead concentrations centered on the geometric mean blood lead concentration.

To use the IEUBK model, EPA must first estimate the in-stream lead concentration (based on the methodology described in section 2.1). EPA then projects the daily ingestion of lead based upon the instream concentration, bioconcentration factor for lead, and fish consumptions rates for children.[7] The IEUBK model then estimates the geometric mean blood lead level. Although, the model can estimate blood lead concentrations from multi-pathway exposure (air, soil, diet, water), all other pathway exposures other than diet were "zeroed out" in order to isolate blood lead levels solely attributable to consumption of lead-contaminated fish.

As noted above, children are primarily adversely affected through intellectual impairment as measured by changes in IQ. EPA estimates the health and monetary benefits from decreasing risks for reduced IQ potential in at-risk populations using the equations used in Lead Benefits Analysis performed for the Retrospective Study of the Clean Air Act (EPA, 1997c). The specific steps used to estimate the health effects benefits based on estimated changes in blood levels is described below:

- EPA uses the "1997 Statistical Abstract of the US" to estimate the percentage of the total US population between 0 and 72 months equal to 0.1031 percent. For each reach, EPA estimates *exposed* child population by multiplying the total exposed population for each reach (recreation and subsistence) by the corresponding percentage of children.

- EPA estimates the change in children's IQ using equation (5) from Appendix G of the Retrospective Study of the Clean Air Act.

$$(Total\ Lost\ IQ)_k = \Delta GM_k \times 1.117 \times 0.25 \times Pop_k/7 \qquad \textbf{(12)}$$

[7] Volume II- Food Ingestion Factors, Exposure Factors Handbook, EPA, August 1997 (USEPA, 1997b).

where:

$(\text{Total Lost IQ})_k$	=	Total Reduction of IQ points in Affected Population
a GM_K	=	Change in the Geometric Mean of Affected Population's Blood Lead Level

For adult populations, EPA estimates health effects using methodology contained in its interim approach for assessing risks associated with adult exposure to lead in soil (*Interim Guidance,* USEPA 1996a).[8]

The approach described in the *Interim Guidance* estimates the effects of ingestion of lead contaminated soil on blood lead levels of women of child-bearing age. The analysis looks at this subpopulation group in order to derive risk-based remediation goals (RBRG) that would be protective of the developing fetus of adult women having site exposure. Although the *Interim Guidance* equation is based on a scenario quite different from that analyzed in the CWT environmental assessment (i.e.; consumption of contaminated fish by recreational and subsistence anglers), the exposure pathways are essentially the same. The main difference being the matrices which contain the lead contaminant (i.e., soil versus fish). The applicable equation (*Interim Guidance*, pg.2. Equation 1) is as follows:

$$(PbB)_{adult'central} = PbB_{adult0} \times PbS \times BKSF \times IR_s \times AF_s \times EF_s/AT \qquad \textbf{(13)}$$

where:

$PbB_{adult'central}$	=	Central estimate of blood lead level concentration (µg/dL) in adults (i.e. women of child-bearing age) that have site exposure to soil lead at concentration, PbS.
$PbB_{adult,0}$	=	Typical blood lead concentration in adults in absence of exposures to the site that is being assessed (The TRW *Interim Guidance* uses a background blood lead level of 2 µg/dL).

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[8] Recommendations of the Technical Workgroup for Lead for Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil, USEPA, December 1996.

PbS = Soil lead concentration (µg/g) (appropriate average concentration for individual).

BKSF = Biokinetic Slope Factor relating (quasi-steady state) increase in typical adult blood lead concentrations to average daily uptake (µg/dL blood lead increase per µg/day lead uptake).(The TRW *Interim Guidance* uses a BKSF of 0.4)

Ir_s = Intake rate of soil, including both outdoor soil and indoor soil-derived dust (g/day).

Af_s = Absolute gastrointestinal absorption factor for ingested lead in soil and lead in dust derived from soil (dimension less).

Ef_s = Exposure frequency for contact with assessed soils and/or dust derived in part from these soils (days of exposure during the averaging period); may be taken as days per year for continuing, long-term exposure.

AT = Averaging time; the total period during which soil contact may occur; 365 day/year for continuing exposures.

EPA has modified the above equation to estimate adult blood lead levels from consuming lead-contaminated fish consumption by modifying the equation as follows:

$$(PbB)_{adult,central} = PbB_{adult0} + IS_c \times BCF \times ING_f \times AF_s \times BKSF \times EF_s \times CF/AT \qquad \textbf{(14)}$$

where:

$PbB_{adult,central}$ = Central estimate of blood lead level concentration (µg/dL) in adults (i.e., adults consuming fish contaminated with lead attributable to CWT discharges.

$PbB_{adult,0}$ = Typical blood lead concentration in adults in absence of exposures to contaminated fish. (2 µg/dL).

Is_c = In stream Concentration of lead (µg/L) (Affected receiving water bodies had in stream concentrations of lead ranging from 0.5 µg/L to approximately 7.7 µg/L).

BCF = Bioconcentration Factor for lead (49 L/kg).

ING_f = Average daily consumption of fish (16.5g/day for recreational anglers and 140 g/day for subsistence anglers).

Af_s = Absolute gastrointestinal absorption factor for ingested lead in fish (.06 dimensionless).[9]

BKSF = Biokinetic Slope Factor relating (quasi-steady state) increase in typical adult blood lead concentrations to average daily uptake (µg/dL blood lead increase per µg/day lead uptake). (EPA uses the 0.4 slope factor as presented in the *Interim Guidance*).

Ef_s = Exposure frequency for ingestion of contaminated fish; (days of exposure during the averaging period); may be taken as days per year for continuing, long-term exposure (365 days).

CF = Conversion Factor 10^{-3} (kg/g).

[9] For both the proposed and final CWT rules EPA used 0.06. However based upon a review of *Measurement of Soil-Borne Lead Bioavailability in Human Adults, and its Application to Biokinetic Modeling* (Maddaloni, 1998) and consultation with the author, EPA now believes that a value of 0.03 may be more appropriate. EPA notes that this lower value would reduce the estimated lead health effect in adults for the CWT final rule making (monetized at $258,000 to $1,358,000 based on the value of 0.06). This reduction of lead health effects in adults may reduce the total estimated monetized benefits of this rule by up to 17 percent.

AT = Averaging time; the total period during which food is consumed; 365 day/year for continuing exposures.

EPA modifies the equation presented in *the Interim Guidance* to account for ingestion of lead contained in fish tissue rather than ingestion of lead contained in a soil matrix. The primary source of uncertainty in applying the *Interim Guidance* equation to the affected CWT population is:

- Using soil lead bioavailability factor to estimate fish lead bioavailability.

The bioavailability of lead ingested in a soil matrix is likely to be different from the ingestion of lead contained in fish tissue. Studies conducted by *Maddaloni* and others that are cited in the *Interim Guidance* indicate that lead ingested with food is absorbed at a significantly lower rate than when lead is ingested without food in a soil matrix. It has been suggested that these lower absorption rates may be due to the presence of chelating substances in food products as well as the fact that readily absorbed food may serve as a physical barrier to absorption of less soluble substances such as lead. To account for the these differences, EPA has modified the absorption rate presented in the *Interim Guidance* (12 percent), which used a "meal weighted average" rate. For purposes of this analysis, EPA uses an absorption factor of six percent. In all other aspects, the equation for soil and for fish ingestion are consistent and require no modification.

<u>Using the Equation to Estimate Benefits to the Affected Adult Population</u>

By using the results of the CWT Modeling efforts and adapting methodology from the *Interim Guidance* EPA conservatively estimates changes in adult blood lead levels for the affected population. The procedure involves a four- step process which estimates:

1. In stream concentration of lead using CWT models described in Section 2.1
2. Lead uptake in affected adult population using the established bioconcentration factor for lead and fish consumption rates for recreational and subsistence anglers.
3. Changes in blood lead levels using *Interim Guidance* methodology described above
4. Changes in health status from final regulations using methodology cited in the *CAA Study*.